CLAIMS

What is claimed is:

1. An airgun, comprising:
a compressed gas chamber;
a barrel;
a firing valve controlling gas flow between the compressed gas chamber and the barrel;
a secondary cylinder connected to the compressed gas chamber;
a secondary piston reciprocating within the secondary cylinder and dividing the secondary cylinder into a front volume connected to the compressed gas chamber and a back volume;
a liquefied gas chamber connected to the back volume of the secondary cylinder;
a valve for transferring a volume of liquefied gas into the liquefied gas chamber;
a cocking mechanism for closing the firing valve, and for at least one of i) filling the compressed gas chamber with a first gas at an elevated pressure, and ii) transferring a volume of a liquefied second gas into the liquefied gas chamber through the transfer valve; and
a firing mechanism for opening the firing valve.

2. The airgun of Claim 1, wherein:
upon cocking of the airgun, the compressed gas chamber is filled with the first gas at an elevated pressure, and the volume of liquefied second gas is transferred into the liquefied gas chamber;
upon cocking of the airgun, pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and further compress the first gas to about a saturation pressure of the second gas; and
upon firing of the airgun, the first gas flows through the firing valve into the barrel, and pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and maintain pressure of

the first gas near the saturation pressure of the second gas during an initial portion of the flow of the first gas into the barrel.

3. The airgun of Claim 2, wherein, upon firing of the airgun and during an intermediate portion of the flow of the first gas into the barrel, pressure exerted by the second gas in the back volume moves the secondary piston so as to at least partially disengage the secondary piston from the secondary cylinder, thereby enabling the second gas to flow into the compressed gas chamber, through the firing valve, and into the barrel.

4. The airgun of Claim 1, wherein:
upon cocking of the airgun, the compressed gas chamber is filled with the first gas at an elevated pressure; and
upon firing of the gun, the first gas flows through the firing valve into the barrel.

5. A method for using the airgun of Claim 4, comprising:
cocking the airgun of Claim 4, thereby closing the firing valve and filling the compressed gas chamber with the first gas at an elevated pressure; and
firing the airgun of Claim 4 by opening the firing valve, so that the first gas flows through the firing valve into the barrel.

6. The method of Claim 5, wherein the first gas is ambient air, and the first gas is compressed to between about 400 psig and about 600 psig in the compressed gas chamber.

7. The airgun of Claim 1, wherein:
upon cocking of the airgun, the volume of liquefied second gas is transferred into the liquefied gas chamber;
upon cocking of the airgun, pressure exerted by the second gas in the back volume moves the secondary piston so as to at least partially disengage the secondary piston from the secondary cylinder, thereby enabling the second gas to flow into the compressed gas chamber; and

upon firing of the airgun, the second gas flows through the firing valve into the barrel.

8. A method for using the airgun of Claim 7, comprising:
cocking the airgun of Claim 7, thereby transferring the volume of liquefied second gas into the liquefied gas chamber, wherein pressure exerted by the second gas in the back volume moves the secondary piston so as to at least partially disengage the secondary piston from the secondary cylinder, thereby enabling the second gas to flow into the compressed gas chamber; and
firing the airgun of Claim 7 by opening the firing valve, so that the second gas flows through the firing valve into the barrel.

9. The method of Claim 8, wherein the second gas is carbon dioxide.

10. The airgun of Claim 1, wherein the compressed gas chamber comprises a primary cylinder and a corresponding primary piston, and the cocking mechanism moves the primary piston within the primary cylinder so as to compress the first gas to the elevated pressure within the compressed gas chamber.

11. The airgun of Claim 10, wherein the cocking mechanism includes:
a lever pivotably connected to the airgun; and
a mechanical linkage connecting the lever and the primary piston,
wherein pivoting of the lever results in movement of the primary piston within the primary cylinder.

12. The airgun of Claim 10, wherein a single stroke of the primary piston within the primary cylinder compresses the first gas to between about 400 psig and about 600 psig.

13. The airgun of Claim 1, further comprising a liquefied gas reservoir, wherein the liquefied gas reservoir is connected to the liquefied gas chamber through the transfer valve.

14. The airgun of Claim 1, further comprising a safety mechanism, wherein:

the safety mechanism must be disengaged for enabling cocking of the airgun; and the safety mechanism must be re-engaged for enabling firing of the airgun.

15. The airgun of Claim 14, wherein disengaging the safety mechanism closes the firing valve.

16. The airgun of Claim 14, wherein the safety mechanism must be disengaged to enable filling of the compressed gas chamber with the first gas at an elevated pressure.

17. The airgun of Claim 14, wherein re-engaging the safety mechanism transfers the volume of liquefied second gas into the liquefied gas chamber.

18. The airgun of Claim 14, wherein the safety mechanism must be re-engaged to enable opening of the firing valve.

19. The airgun of Claim 1, wherein the cocking mechanism includes a lever pivotably connected to the airgun, and a mechanical linkage connected to the lever for closing the firing valve.

20. The airgun of Claim 1, wherein the cocking mechanism includes a lever pivotably connected to the airgun, and a mechanical linkage connected to the lever for actuating the transfer valve.

21. The airgun of Claim 1, wherein the first gas comprises ambient air.

22. The airgun of Claim 1, wherein the second gas comprises carbon dioxide.

23. The airgun of Claim 1, wherein the transfer valve comprises a shuttle valve.

24. The airgun of Claim 1, further comprising a passage for enabling gas to vent from the back volume during filling of the compressed gas chamber with the first gas and prior to transferring the volume of liquefied second gas into the liquefied gas chamber.

25. The airgun of Claim 1, wherein:

upon cocking of the airgun, the compressed gas chamber is filled with the first gas at an elevated pressure, and the volume of liquefied second gas is transferred into the liquefied gas chamber;

upon cocking of the airgun, pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and further compress the first gas to about a saturation pressure of the second gas;

upon firing of the airgun, the first gas flows through the firing valve into the barrel, and pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and maintain pressure of the first gas near the saturation pressure of the second gas during an initial portion of the flow of the first gas into the barrel;

upon firing of the airgun, during an intermediate portion of the flow of the first gas into the barrel, pressure exerted by the second gas in the back volume moves the secondary piston so as to at least partially disengage the secondary piston from the secondary cylinder, thereby enabling the second gas to flow into the compressed gas chamber, through the firing valve, and into the barrel;

the first gas comprises ambient air; and

the second gas comprises carbon dioxide.

26. The airgun of Claim 25, wherein:

the elevated pressure of the first gas is between about 400 psig and about 600 psig; and

muzzle energy of the airgun remains between about 12 ft-lb and about 14 ft-lb over a temperature range between about 45° F and about 85° F.

27. The airgun of Claim 1, wherein:

the airgun further comprises a liquefied gas reservoir connected to the liquefied gas chamber through the transfer valve;

the transfer valve comprises a shuttle valve;

the compressed gas chamber comprises a primary cylinder and a corresponding primary piston;

the cocking mechanism includes a first lever pivotably connected to the airgun and a mechanical linkage connecting the lever and the primary piston, and pivoting of the lever results in movement of the primary piston within the primary cylinder, so that cocking of the airgun by pivoting the first lever results in movement of the primary piston within the primary cylinder so as to compress the first gas within the compressed gas chamber;

the first lever includes a safety latch, wherein the safety latch must be disengaged for enabling pivoting of the first lever and cocking of the gun;

the cocking mechanism includes a second lever pivotably connected to the airgun and mechanically linked to the safety latch so that disengaging and re-engaging the safety latch result in pivoting movement of the second lever;

the second lever is mechanically linked to the firing valve so that disengaging the safety latch closes the firing valve;

the second lever is mechanically linked to the firing valve so that the safety latch must be re-engaged to enable opening of the firing valve;

the second lever is mechanically linked to shuttle valve, so that disengaging the safety latch transfers the volume of liquefied gas from the reservoir and re-engaging the safety latch transfers the volume of liquefied second gas into the liquefied gas chamber; and

the airgun further comprises a passage for enabling gas to vent from the back volume during compression of the compressed gas in the compressed gas chamber and prior to transferring the volume of liquefied second gas into the liquefied gas chamber.

28. A method for propelling a projectile from an airgun, comprising:

closing a firing valve;

filling a compressed gas chamber of the airgun with a first gas at an elevated pressure, wherein

the compressed gas chamber is connected to a barrel of the airgun through the firing valve,

the compressed gas chamber is connected to a front volume of a secondary cylinder and a secondary piston reciprocates within the secondary cylinder and divides it into the front volume and a back volume, and

filling the compressed gas chamber results in movement of the secondary piston so as to increase the front volume and reduce the back volume;

transferring a volume of a liquefied second gas into a liquefied gas chamber connected to the back volume, wherein pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and further compress the first gas to about a saturation pressure of the second gas;

opening the firing valve so that the first gas flows through the firing valve into the barrel, wherein pressure exerted by the second gas in the back volume moves the secondary piston so as to reduce the front volume and maintain pressure of the first gas near the saturation pressure of the second gas during an initial portion of the flow of the first gas into the barrel.

29. The method of Claim 28, wherein, during an intermediate portion of the flow of the first gas into the barrel, pressure exerted by the second gas in the back volume moves the secondary piston so as to at least partially disengage the secondary piston from the secondary cylinder, thereby enabling the second gas to flow into the compressed gas chamber, through the firing valve, and into the barrel.

30. The method of Claim 29, wherein:

the first gas comprises ambient air;

the first gas is compressed to between about 400 psig and about 600 psig;

the second gas comprises carbon dioxide; and

muzzle energy of the airgun remains between about 12 ft-lb and about 14 ft-lb over a temperature ranges between about 45° F and about 85° F.

31. The method of Claim 28, wherein the compressed gas chamber comprises a primary cylinder and a corresponding primary piston, and movement of the primary

piston within the primary cylinder so as to compress the first gas to the elevated pressure within the compressed gas chamber.

32. The method of Claim 31, wherein a single stroke of the primary piston within the primary cylinder compresses the first gas to between about 400 psig and about 600 psig.

33. The method of Claim 28, wherein the liquefied second gas is transferred from a liquefied gas reservoir of the airgun through a transfer valve into the liquefied gas chamber.

34. The method of Claim 28, further comprising:
disengaging a safety mechanism of the airgun, thereby closing the firing valve and enabling filling of the compressed gas chamber; and
re-engaging the safety mechanism, thereby transferring the liquefied second gas and enabling opening of the firing valve.

35. The method of Claim 28, wherein the first gas comprises ambient air.

36. The method of Claim 28, wherein the second gas comprises carbon dioxide.

37. The method of Claim 28, wherein the transfer valve comprises a shuttle valve.

38. The method of Claim 28, further comprising venting gas from the back volume during compression of the first gas in the compressed gas chamber and prior to transferring the volume of liquefied second gas into the liquefied gas chamber.